LI.—*A Description, with Illustrations, of the Development of* Sorastrum spinulosum, *Näg.*; *to which is added that of a new Form of* Protococcus. By Henry J. Carter, F.R.S. &c.

[Plate XIV.]

Introductory Remarks.

On the 29th of January of the present year (1869), I collected a little of the surface-mud and water of a pool in a heath-bog about a mile from this place (Budleigh-Salterton), and, having poured it into one of those three-and-half-ounce greenish glass gum-bottles, of a pyramidal shape (that is, flat and expanded at the bottom, with a narrow mouth), in which a solution of gum is now generally sold in the shops for adhesive purposes, I submitted some of it to immediate examination; and finding that it contained many sporangia, together with large *Pinnulariæ*, I resolved to keep it throughout the spring, to see what changes might take place in either; for, from the presence also of many Desmids, especially *Closterium*, I thought that some of the sporangia might belong to the latter.

The gum-bottle was kept on a table close to a window facing due west; and time after time portions of the sediment were extracted with a dip-tube and placed under the microscope for examination, while the water in the bottle was replenished from a deep well, as required.

It was not, however, until about the second week in June that I began to find many of the sporangia developing filaments of *Spirogyra* and *Zygnema* respectively, which, accumulating, soon floated to the surface of the water in a dense mass. The *Pinnulariæ* presented no change beyond an increase of their glairy globular contents; but a great many sporangia remained, in some of which I still hoped to see the development of some Desmid.

On the 18th July this long-looked-for phenomenon seemed to present itself, by the presence *in* a sporangium under observation of a triangular organism so very like the Desmid *Staurastrum dejectum* (Ralfs, Desmid. pl. 20. fig. 5) that I made sure of having found the zygospore of at least one kind of Desmid under development.

It was not likely, therefore, that I should throw away this opportunity, and so I took the measurements of the sporangial cell and of all its contents respectively; but in doing this, it became evident to me that the triangular Desmid was not the one I had taken it for, but another, of a kind with which I was unacquainted.

This made me still more particular; and so I not only

measured, but sketched and described all the contents of the sporangial cell, when it further became evident that there was but one large triangular individual present, and that the rest consisted of groups containing eight each of the same form, but of a much smaller size.

From this period up to the 9th of August (an interval of three weeks) various interruptions prevented my return to the examination of the contents of the gum-bottle; but at this date, to my surprise, I found similar groups of the unknown Desmid, which I had previously sketched *in* the sporangium, free (that is, unenclosed in any cell whatever), much enlarged, and very numerous.

I then turned to Pritchard's 'Infusoria' (ed. 1861), and in his first plate, figs. 57 & 58, found almost identical representations of this organism, which, on referring to the text among the Desmidieæ, at p. 755, proved to be *Sorastrum spinulosum* Näg., of which it was stated "Propagation unknown," with the letter "G," indicating that it had only been found in Germany. Next I sought for it in Kützing (Species Algarum, 1849), where I found it, at p. 195, constituting a genus, but still placed among the Desmidieæ. Lastly, I consulted Rabenhorst (Flor. Europ. Algarum, 1868), where, with figs. no. 38, p. 18, and text p. 81, it is placed among the Protococcaceæ as the 49th genus of his Coccophyceæ.

Not knowing whence the figures in Pritchard had been taken, or whether *Sorastrum* had been found in the British Isles, I wrote on the subject to Mr. W. Archer, of Dublin (whose revision of the Desmidian group in Pritchard's last edition of the Infusoria has so greatly contributed to the success of this useful publication); and, in reply, Mr. Archer stated that the figures were taken from Nägeli's Unicellular Algæ (Gatt. einz. Alg. pl. 5. fig. D, *b* & *d*), but that, since they had been copied into Pritchard, Mr. Archer had seen *Sorastrum spinulosum* "many times and in various places in Ireland, but always very scant and sparing." Moreover Mr. Archer kindly presented me with copies of the 'Proceedings of the Dublin Microscopical Club' (preeminent in all matters of this kind for their accuracy and interest), wherein a "brief" description of *Sorastrum spinulosum* is given from specimens exhibited before the meeting of the Club held on the 21st Sept. 1865, p. 40, and subsequent mention of it again (having been found by the same author) at their meeting held on the 19th July, 1866, p. 101. To Mr. Archer's description I shall have again to refer hereafter; meanwhile let us return to the developmental history of those specimens of *Sorastrum* more immediately under our consideration.

Finding that I had an abundance of this organism produced in the way above mentioned, I continued to examine several of them daily, limiting myself to six dips of the the dip-tube *per diem*, and on the 10th and 11th of September saw, for the first time, a *small* group attached to a large one, in one dip, and in the contents of another dip an isolated individual of a large group with the spines on one side much retracted, and on the other side almost entirely obsolete.

Both these phenomena combined were again presented to me in the afternoon of the 17th of September; and I then succeeded in transferring the group and its now *two* young ones (baby groups) to a cell depression in a glass slide filled with water, over which a cover was placed for protection and to prevent evaporation. (I prefer the term "baby" to "daughter groups," because it will be seen hereafter that some of these groups might be spermatic elements—microgonidia.) About 7 P. M. of the same evening it was observed that two more groups had been produced, and on the morning of the following day (that is, on the 18th Sept.) that another group had been eliminated during the night, making, in all, five young groups, four of which were respectively enclosed in delicate spherical transparent capsules, all of them, no doubt, provided by the parent cell or individual. (Pl. XIV. fig. 6.)

Here the development of the baby groups appeared to cease; and on the 19th Sept. the whole was placed on the flat surface of a glass slide, for compression and final examination, when several empty individuals came into view, and the individuals of the parent group which still retained their gonimic contents were observed to have become much rounded, and to have their spines more or less atrophied.

After this, many instances of large groups were seen with baby groups about them, and one in particular in which a 16-division group of empty individuals was accompanied by from eight to ten baby groups, all in delicate capsules.

While this was going on, a dark sea-green sporangium, 13-6000ths of an inch in diameter, with gelatinous envelope, began to appear, viz. on the 6th Sept., and after this was frequently observed, which sporangium was so like in colour and contents to *Sorastrum spinulosum*, and so different from every other kind of sporangium in the gum-bottle, that I had little doubt that it was the impregnated sporangium of our *Sorastrum*. But, as this identity will come out better by the descriptive detail of this development in the summary of my observations which follows, I will add no more here than that the presence of this spore seemed to terminate, for this year, all that I was likely to see in the development of this little

plant. The large groups, the baby groups, and the said sporangia all abounded in the gum-bottle at the end of Sptember.

Summary of Observations.

We will divide the development into four stages, viz.:— 1st, the development of the groups of *Sorastrum* from the sporangium; 2nd, the growth of these groups; 3rd, the production of the baby groups and consequent evacuation of the gonimic contents of some of the individuals of the parent group, together with the retention of these contents by others, accompanied by change in figure of the body (inflation) and atrophy of their spines; and, 4th, the formation of the sporangium.

1. On the 18th July, a spherical transparent cell, 18-6000ths inch in diameter, was observed in a drop of the sedimentary contents of the gum-bottle mentioned, which contents had been placed under a microscope for examination. This cell contained fifteen spherical groups of the compound *Protococcus* called *Sorastrum spinulosum*, Näg., each group consisting of eight individuals and one large individual by itself, thus dividing the contents of the sporangial cell into sixteen portions. Each of the groups was 5-6000ths inch in diameter, and each individual composing them about 2-6000ths inch broad, while the single individual was 4-6000ths inch broad (Pl. XIV. fig. 4). The centre of the sporangial cell was occupied by another spherical cell (*e*) 3-6000ths inch in diameter, which, again, was apparently filled with small cells around one a little larger, which was in the very centre of all; while from the spherical towards the confines of the sporangial cell were seen the remains of the radiating branched septa (*f*), which originally divided the contents of the sporangium into sixteen compartments.

2. On the 14th August following, a great number of free groups (that is, without cell-envelopes) were seen, averaging 8-6000ths inch in diam., exclusive of the spines, and composed respectively of eight, sixteen, and thirty-two individuals, of which each individual averaged 4-6000ths inch broad (fig. 1). The largest groups measured 16-6000ths inch in diameter, and the largest individuals 5-6000ths inch broad (figs. 2 & 3).

3. On the 10th of September, baby groups began to appear in connexion with the large groups; and one of these groups, where there were two baby groups present, was transferred for further observation to a cell depression in a slide covered with a thin bit of glass, as before stated, for protection and to prevent evaporation. Here, in the course of twelve hours afterwards, three more baby groups were produced, making in all five, of which four were composed of sixteen individuals each,

and each group eliminated in its proper cell, while the other group, consisting of eight individuals, appeared to have lost its cell, and presented a tendency to disintegration or separation of its individuals. All these groups were 3-6000ths inch in diameter, exclusive of the cell (which was a little larger), and the individuals composing them 1½-6000th inch broad, while the individuals of the parent group averaged 5-6000ths inch broad.

When all development of the baby groups appeared to have ceased, the whole was transferred to the level surface of a glass slide and compressed, in order that the total number of individuals in the parent group might be ascertained, if possible, together with the number of those which were empty and collapsed and of those which still retained their gonimic contents, for the purpose chiefly of ascertaining the relation in number of the five baby groups to that of the individuals of the parent group (fig. 6). This gave two of the former (*b b*), seven of the latter (*a*), and five baby groups (*c*); but, as will presently appear, all the empty individuals were not visible. (See all this delineated in fig. 7.)

Further, to ascertain the alterations in form which the individuals still retaining their gonimic contents had undergone in their cell-walls and spines respectively, as there was already evidence of something of this kind having taken place, and to determine, if possible, how many individuals composed the original group, the whole was subjected to a still greater amount of compression, viz. sufficient to burst the green individuals and get rid of their contents (fig. 7), when it was observed that, in addition to these seven (*a*), there were the cells of *four* empty collapsed ones, and the remnants of some more which had never been fully developed, or, if so, had only left fragments of their cells attached to the rest (*b b*).

Thus there was evidence of four distinct empty cells and the remains of some others; so that the original group, probably, belonged to the 16-division.

This was not all; for the cell-walls of the green individuals had not only become larger, rounder, and more inflated by an actual increase in their gonimic contents, but the spines in several of them had become so far atrophied that here and there they were entirely gone or represented only by a little papillary eminence (*c c*)—an alteration which had previously been witnessed in isolated individuals drawn up among the sediment by the dip-tube.

I have already mentioned the appearance of another group of sixteen individuals (or of the 16-division *cell*), the whole of which were collapsed and empty, with the presence of from eight

to ten baby groups around them, while the phenomena of enlargement, approach towards a globular form, and atrophy of the spines have just now (October 19th) been most satisfactorily seen in one group of eight and in three groups of sixteen cells each. (These specimens were taken from another gum-bottle, in which a little of the sediment of the original one had been placed about two months since, together with some small bits of the jelly of *Ophrydium versatile*, and where *Sorastrum*, thus transferred, has multiplied as much as in its original bottle, with even more robust dimensions.)

The sediment of the original gum-bottle now became charged with the old (fig. 1) and the new (fig. 8) groups of *Sorastrum*, so that from six to ten old and young might be counted in each drop of the sediment when placed on the slide for examination.

4. To those who had observed the contents of any algal cells (especially those of the so-called unicellular Algæ), respectively divided up into microgonidia and macrogonidia, and the former swarming round and passing into the latter for impregnation, as in *Cryptoglena lenticularis*, Cart. (Annals, ser. 3. vol. ii. pl. 8. figs. 18–27), it would not be unlikely that, on witnessing a similar elimination in *Sorastrum spinulosum*, this should also be set down as the time for impregnation and formation of the spore. Hence I was not surprised to see for the first time (viz. on the 6th of September) a spherical sporangium, 13-6000ths inch in diam., densely filled with gonimic contents presenting a deep dark sea-green colour, precisely like that of the groups of *Sorastrum*, and totally different from that of everything else in the gum-bottle (fig. 9).

Moreover, on minutely examining this sporangium, it was observed to be invested with a soft gelatinous transparent envelope (*a a*), and to possess a tough transparent coat (*b*), which, when burst, was found to be filled with the usual contents of a sporangium, viz. minute grains of starch, chlorophyll, oil-globules, &c., but no distinguishable nucleus.

Subsequently this sporangium became more abundant, and in some cases double, but always presented the same size and other characteristics mentioned, with the exception that occasionally it appeared to be a little elliptical.

How and when this sporangium was produced, assuming it to be that of *Sorastrum*, I can only conjecture from the resemblance of the baby groups eliminated in the third stage, corresponding to that which I had seen to be the moment of impregnation in the unicellular Alga to which I have alluded, where some of the groups eliminated were in the form of microgonidia and others in that of macrogonidia, *i.e.* of minute

spermatic elements, ciliated and active, and of larger germic ones, entirely passive. Hence the reason, to which I have before alluded, for using the term "baby" instead of "daughter groups" for those thus eliminated from *Sorastrum*.

How, again, to give a right interpretation to the alteration in the form of the individuals of the parent group which retain their gonimic contents, and lose their spines, apparently by atrophy, I am ignorant. This may be a passive or winter form assumed by the individual; or if, as in *Œdogonium* (see my figures, 'Annals,' ser. 3. vol. i. p. 29), a kind of micropyle or opening is formed in the original cell-wall for the entrance of the microgonidia to the spore, then the enlarged green individuals, which become rounded and lose their spines, may be females becoming impregnated and thus passing into sporangia instead of into passive winter forms. But, in the absence of more decided proof, I must leave the reader, in this matter, to his own conjecture, merely adding that in no instance have I seen the cuneate individual of a parent group producing a series of baby groups endogenously or within its cell-wall, arranged around a central cell, like that observed in the sporangial cell (fig. 4). Nor have I ever seen an individual of a parent group undergo binary division or fissiparition to increase the number of individuals in that group, although it might be conceived that the bilobate condition which I shall have to notice presently might easily lead to this kind of multiplication.

Thus ends the development of *Sorastrum spinulosum*, so far as I have been able to pursue it. The formation of the sporangium brings us back to that stage which was witnessed on the 18th of July last, where we found the sporangial cell producing sixteen groups; and we must wait for July of 1870, probably, to verify the conclusion that the sporangia now presenting themselves are really those of our beautiful little *Sorastrum*. Meanwhile I hope to keep all safely, with occasional examination, until that time arrives.

Species.

It is too much the custom with naturalists to give a name to every new organism of which they have caught but the merest glimpse and could make the roughest representation. Then comes a second, who sees more of the same organism, and therefore gives it another name, and so on; there may be a third, or more, increasing in a short time the synonymy to such an extent that, with myself, it often threatens to paralyze all further efforts at investigation where it occurs. And where

does it not in the *après-moi-le-déluge* system of those reckless *soi-disant* "naturalists" whose chief object is to see their names dangling after a description oftentimes incomplete and sometimes even culpably imperfect?

I do not mean this to apply to the present instance; but when one reads in Mr. Archer's faithful description of *Sorastrum spinulosum* (Proceed. Dublin Microscop. Club, 21st Sept. 1865, p. 40), that, although each individual of the group of *Sorastrum* possesses four spines, when one individual "presents its broad or cuneate side to the observer, it often happens that only two spines seem to exist, as one is behind and hidden by its companion" (a condition which I myself have often witnessed)—again, when one sees that the individual of *Sorastrum spinulosum* is often "bilobate," as represented in fig. 5 (*a*), perhaps from atrophy, as the reverse becomes the case in robust individuals (*b*, *c*, *d*), one cannot help thinking that, in these two conditions combined, it is just possible that Meneghini's *Sorastrum echinatum* (Synops. in Linn. xiv. p. 238. n. 4) of 1840 may be Nägeli's *S. spinulosum* (Einz. Alg.) of 1849 and Rabenhorst's *S. bidentatum* (Flor. Europ. Alg.) of 1868—all phases of one and the same individual which I have often seen manifested among the different groups of the *Sorastrum* under consideration, and therefore trifling differences which I do not think warrant the separation.

If priority of notice gives precedence, then it seems to me that Meneghini's name of *Sphærastrum echinatum* for this little plant should be retained. Kützing, also, has changed "*Sphærastrum*" to "*Sorastrum*," or at all events adopted Nägeli's appellation (which is the latter) for the genus.

Making a "heap" of it, instead of a "sphere," seems to me like requiring a little more when enough has been attained, or risking the substance for the shadow—a course which too often breaks down the memory with disgust, and, if continued, must sooner or later be altogether suicidal to natural history.

There is one point, however, in which all the representations and descriptions of this little organism appear to be deficient, viz. in the mention of a stipes (fig. 2 *a*), whose presence, as my figures will show, necessitates the addition of "stipitate" to its cuneate outline.

From the triangular form of, and spines on, the individual of *Sorastrum*, resembling especially *Staurastrum avicula* and *S. dejectum* (Ralfs, Desmid. pl. 23 and pl. 20, figs. 11 & 5 respectively), it has hitherto been placed among the Desmidieæ; but the latter, although much about the same size as the cuneate individual of *Sorastrum*, appears in pairs, united by a

bond of attachment which extends from centre to centre of the proximate flat triangular sides of the divisions, while two pairs unite to form the zygospore, which is echinated. On the other hand, the individual of *Sorastrum* is spined *only* at two ends, the other corner of the cuneate cell being stipitate, while in its normal condition it forms one of a group of eight, sixteen, or thirty-two individuals. The latter, again, do not appear to undergo binary division, but produce one or more baby groups of *Sorastrum*, and, if we are right in our conjecture, a smooth sporangium, formed probably from the impregnation of a macrogonidium by microgonidia.

Thus the former, by its zygospore, is essentially a Desmid, and the latter, by its mode of generation, essentially allied to *Pediastrum* (see A. Braun's figures &c. of the development of *Pediastrum granulatum*, pl. 3, in 'Rejuvenescence of Nature,' translated in Botanical Reports by Henfrey, Ray Soc. Pub. 1853)—a view at which Mr. Archer had also arrived by having frequently witnessed the evolution of young groups from *Cœlastrum* and *Scenedesmus*. Hence, in his last letter to me, this able authority states:—"At present, and so far as observation has yet gone, I could assume *Sorastrum* (as well as *Pediastrum*, *Cœlastrum*, and *Scenedesmus*) as not belonging at all to the Desmidieæ." Of course the observations which have led to this conclusion have been made since the last edition of Pritchard was published, in which these genera are all placed by Mr. Archer, as heretofore, among the Desmidieæ. Further, Mr. Archer's present view is also corroborated by Rabenhorst, who (*op. cit.* 1868) has assigned all these genera to his family of Protococcaceæ.

(It is curious, too, as showing the gradual development of our knowledge in these respects among people widely separated and without intercommunication, although probably of contemporaneous education previously, in the same kind of seminaries, that, in the month of June 1861, I had myself made drawings of *Pediastrum*, *Scenedesmus*, &c., to show at some future period that these organisms belonged rather to the Protococcaceæ than to the Desmidieæ.)

Although, however, Rabenhorst figures and places all these genera under his family Protococcaceæ as "*Algæ unicellulares sensu strictissimo*," still a group of eight, sixteen, or thirty-two individuals linked together in the form of *Sorastrum* can hardly be considered "unicellular," any more than the concatenated cells of a filament of *Spirogyra*. But, be this understood as it may, these organisms, for reasons above stated, undoubtedly belong much more to the Protococcaceæ than to the Desmidieæ.

General Observations.

Thus we have seen (1) that the development of *Sorastrum spinulosum* commences by a division of the contents of the sporangium into sixteen portions or family groups of eight (sixteen, or thirty-two ?) individuals each; (2) that, after elimination, these groups increase in size, but not in number of individuals, so far as my observation extends; (3) that certain individuals produce one or more family groups of eight, sixteen, or thirty-two individuals each, in cells respectively provided by the parent, which are deciduous (that is, subsequently soon disappear); (4) that those individuals of the parent group which do not produce new families retain their gonimic contents, increase in size, become globular, and lose their spines by atrophy; (5) that a spherical or slightly elliptical sporangium, about twice the diameter of the largest individual of a group of *Sorastrum*, makes its appearance, presenting a deep dark sea-green colour, precisely like that of *Sorastrum*, composed of a tough, transparent coat filled with the usual contents of a sporangium, and surrounded by a thick, soft, transparent, gelatinous envelope.

It may now be asked, upon what grounds I assume that the first development of *Sorastrum* witnessed was that of the sporangium. To which it may be replied, that it presented features which none of the other developmental forms possessed, viz. a large spherical cell containing sixteen family groups, while no other but the "baby" group was enclosed in a proper cell, and the cell of this group was deciduous. Again, no other developmental form of the kind presented itself after the 18th July; but, on the contrary, a great number of groups of eight, sixteen, and thirty-two individuals made their appearance, followed, after the 10th of September, by a still greater number of baby groups which *they* produced. Hence there was a direct sequence in the appearance of the sporangium, the free parent groups, and the baby groups respectively.

A more perplexing question, however, is the signification of the increase of size, rounded form, and atrophy of the spines in those individuals of the group which retained their gonimic contents but did not produce baby groups. This I cannot answer further than that these may pass into winter forms, or, being impregnated, resolve themselves into sporangia.

Nor has the mode of impregnation been witnessed. But here, I think, it may be fairly assumed, from what has been seen in the impregnation of a unicellular Alga (Annals, *l. c.*), that, on the evolution of the gonimic contents (in September)

in the form of small groups of still smaller individuals (although, perhaps, of different sizes in their respective groups, as the latter consisted of eight, sixteen, or thirty-two individuals), we had the elements of impregnative generation, at least the spermatic or microgonidia, if not the germic or macrogonidia also—some of which groups retained their figure entirely, and increased slightly in size, while others became disintegrated. The former having lost the cells provided by the parent, respectively remain on in the gum-bottle; but whether they will live to go through the winter, growing into large groups for further development next year, has yet to be proved, while on the other hand, they may all perish, and the individuals of the parent groups *alone* form the winter or passive stock. The latter were too minute to follow; indeed it was difficult, from their smallness, to conjecture even the total number in each group. They, on separation, might have become ciliated and active, for the purpose of searching out the female passive cell; but although in one or two instances I saw them after disintegration, they had then a globular shape, but were stationary—that is, evinced no movement. These disintegrated stationary ones, too, were probably abortive; for when in full force and normal development, the spermatic cells bound off from the disintegrating group in quest of the passive females ready at the same moment to receive them, and soon disappear, either by entering into them or by becoming still forms (that is, losing their cilia) from failing of their object, and thus, sooner or later, perishing altogether. Hence, except by a stroke of great good fortune, it is almost impossible to follow them after they have left the parent group.

How beautifully is the object of Nature obtained by making only one element of impregnation active! Conceive the confusion that might exist were both elements active in vegetable infusions, where such beings are almost as thick as grains of sand on the sea-shore, and in species almost as infinitely numerous.

Lastly, we come to the formation of the sporangium, which was first seen, on the 6th of September, almost synchronously with the evolution of the baby groups and the change of form &c. in the individuals of the parent group which did not part with their gonimic contents, or, in other words, whose contents were not evolved in the form of the baby groups. And this brings us to the question whether these individuals are female cells, and whether their impregnation takes place through some preparatory opening in their cell-wall, to form the sporangium, or whether the contents of the individual are first eliminated in the form of a free macrogonidium, to receive the

spermatic element *outside the old* cell, as in *Cryptoglena lenticularis* (Annals, *l. c.*).

I confess that the changes which take place in the individuals which do not send forth their contents in the form of baby groups now inclines me to think that the sporangium may be produced after the plan first mentioned. But it will be seen that this is a point still undecided, and, as before stated, one which nothing but a stroke of great good fortune can determine.

It might be asked, also, what are those little cells seen in the central cell of the sporangium under development, and in the central cell also of the groups respectively (figs. 4 & 5, Pl. XIV.)? In the first place, are they cells, or are they circular marks resembling cells, produced by the attachment of the expanded podal ends of the stems of the individuals of the group, respectively, on the central cell? I incline to the latter view, but admit that I am still in doubt as to the real nature of these apparent cells.

Do the individuals which produce baby groups produce more than one, as the cells of *Pediastrum granulatum* (see A. Braun's figures, *l. c.*)? Yes. In the group with two baby groups, which I placed aside for examination, one of the parent individuals was but half emptied, and the following morning it was wholly so, while at the final examination there were only four empty cells and five baby groups. Hence one must have produced two; and this probably was that which at first I saw half-emptied—that is, still retaining another baby group. It is possible, and probable too, therefore, that one parent individual may produce a plurality of baby groups, as in *Pediastrum*.

Thinking that *Sorastrum spinulosum* might be found in the pond of the heath-bog from which was obtained the original sediment in which it was developed in the gum-bottle, I sought for it there about the time that it was most numerous in the latter, but failed to find it anywhere. It is true that the original pool had been drained; but there were several other depressions of the same kind, in the same locality, filled with bog-water, which, on microscopical examination, did not yield a single specimen.

Before concluding this communication, I have to allude to a green *Protococcus* which I found singly and undergoing subdivision in a tank in the Island of Bombay in June 1861, viz. at the time I was led to the view, already noticed, that *Pediastrum*, *Scenedesmus*, and other forms of the kind present in the same

tank belonged to the Protococcaceæ rather than to the Desmidiaceæ.

The peculiarity in this *Protococcus* was, that it presented a conical elongation of, or appendix to, its cell, comet-like, not only in its single form, but throughout all its subdivisions—a feature which I had not previously seen, and which, as it does not appear to have been recorded by others, seems deserving of the accompanying delineations (Pl. XIV. figs. 10–20) and of being described under the following appellation :—

Conococcus elongatus, mihi.

Passive form unicellular, with the usual green contents and nuclear (?) vesicle of such organisms enclosed in a spherical cell, to which is appended a transparent conical extension or appendix three times the diameter of the cell in length. Conical extension persistent in all the individuals of its various subdivisions. Size of single largest cell 4-5600ths of an inch in diameter.

Hab. Fresh water.

Loc. Tanks in the Island of Bombay.

Obs. Sometimes, as in fig. 18, the gonimic contents of the cell are partially extended into the conical appendix; or they may be extended throughout that of one individual only (fig. 19); or they may be extended throughout the whole in the eight-cell division or group, as in fig. 20. Hence the appendix here is actually an "extension" of the cell-wall.

This is the form which I have figured and to which I have alluded in the 'Annals' of April last (1869), pl. 17. fig. 21. I have never seen it in its active state, and am still inclined to think that it may be but a sportive form of the "*Chlamydococcus*" represented in the 'Annals' of 1858, vol. ii. pl. 8, which is the common or usual figure of this unicellular Alga in the tanks of Bombay.

Postscript.

Since the above was written, the question of fissiparity in *Sorastrum* seems to be determined in the affirmative; for on the 30th October a group of eight robust individuals was observed, in which one was much larger than the rest and almost spherical in shape, simulating the roundness and appearance of a sporangium; but, on evacuation of its green contents, the cell-wall was found to present four pairs of spines, situated, apparently, opposite to, and equidistant from, each other, thus indicating the preparatory stage to fissiparition or binary division. It is right, however, to add that only seven spines were actually visible, and that the unseen one of the fourth

pair, if present, was probably concealed behind its companion.

This group was found among the portions of jelly of *Ophrydium versatile* &c. which had been placed in the second gum-bottle mentioned, together with another group consisting of *four* individuals. Indeed, as I have before stated, the second gum-bottle now furnishes the finest groups of *Sorastrum*, both collectively and individually, the former being, for the most part, 13-6000ths inch in diameter, and the individual cell upwards of 5-6000ths inch broad. If the individuals of a group have become unusually large and rounded (that is, 6-6000ths inch in diameter), very slight pressure seems to separate them, when they leave their stems behind and present such an even round outline, in lieu of the cuneate extremity, that no one would suppose there had ever been a point of attachment there, although the spines still remain the same; and this, perhaps, may account for the absence of the stem in Nägeli's and Rabenhorst's figures respectively. The reverse is the case in the earlier part of their career, where the group may be torn to pieces, but the stems remain almost inseparably attached to the individuals.

I have now seen, at one time or another, individuals singly, and in groups of two, four, eight, sixteen, thirty-two, and, I think, sixty-four, which, with the enlargement of the single individual of the group of eight mentioned, and its four pairs of spines, &c., leads to the following inferences:—

That *Sorastrum* may increase by binary division like other unicellular Algæ of the kind; that this may take place in a single individual isolated from the main group (which might thus originate a new group), or in a single individual while attached to the main group, or in all the individuals of a group synchronously; that the enlarged and rounded state of the individual, and not the more or less bilobate form, indicates the preparatory stage to binary division; that, as a single individual of a group may precede the rest in binary division, so the groups may not always be a multiple of 2, although generally so, nor have 2 for a common multiplier (that is, that one individual only of a group of eight, dividing, would give nine, &c.); that, contrary to what has been before inferred, the groups need not always contain the same number of individuals as when first eliminated from the sporangium, but may be increased in this respect by binary division, after elimination; that the enlargement and sphericity of the individual therefore may not lead to the formation of the sporangium, whatever the atrophy of the spines may indicate, while, on the other hand, the contents of the individual may be liberated from

its cell in the condition of a macrogonidium, singly or in plurality, previously to impregnation and the formation of the sporangium, as in *Cryptoglena lenticularis* (*l. c.*) and other Algæ of the kind; lastly, that the facility with which the enlarged and rounded individuals of a group may be separated indicates that this may take place naturally, and thus that each individual may originate a new group, also as in unicellular Algæ generally.

EXPLANATION OF PLATE XIV.

All the figures of *Sorastrum spinulosum*, Näg., are drawn on the scale of 1-6000th to 1-12th inch, in order that their relative sizes may be seen. *Conococcus elongatus*, n. sp., fig. 10, is on the scale of 1-5400th to 1-12th inch; figs. 11 & 12, 1-5400th to 1-24th inch. The rest of the groups were all smaller in size, although their cells individually might, on separation, attain much larger dimensions.

Fig. 1. *Sorastrum spinulosum*, Näg., typical form of cœnobium or group of sixteen individuals; average size 8-6000ths inch in diameter.

Fig. 2. The same, individual of largest size separated from the group, showing the body containing nuclear (?) vesicle: *a*, stipes. Size 5-6000ths inch broad by 4-6000ths long; spines and stipes each $1\frac{1}{2}$–6000th inch long.

Fig. 3. The same, end view, outer side.

Fig. 4. The same, sporangium, 18-6000ths inch in diam., undergoing development of its contents internally, presenting fifteen groups of eight individuals each and one single individual, = sixteen groups, but here represented with four groups only, for perspicuity, viz. two of sixteen individuals each (*a a*), each group 5-6000ths inch diameter and each individual 2-6000ths broad, one of eight individuals (*b*) of the foregoing diameter and breadth of individual respectively, and one single individual (*c*) 4-6000ths inch broad. The four circles (*d d d d*) are intended to show the position of some of the other groups, of which the whole (viz. sixteen) were respectively developed in separate compartments indicated by the septal lines (*f*) extending outwards from the central cell, which groups, though actually all seen by alteration of the focus of the microscope, could not be delineated altogether, and were too indistinct and confused to admit of anything but the arbitrary and imaginary arrangement of them given in the figure. Central cell (*e*) spherical, 3-6000ths inch in diameter, representing a central circular area surrounded by a number of smaller cells.

N.B. In my original Notes, the whole of the groups in this sporangium, with the exception of the single individual (*c*), are set down as containing only eight individuals each; but as many of the groups subsequently seen in the contents of the gum-bottle consisted of sixteen or thirty-two individuals, and these seemed to have come originally from sporangia of the same kind and in the same way, I have delineated two of the groups (*a a*) with sixteen instead of eight individuals each, conjecturally.

Fig. 5. The same, a group of six individuals of the largest size, which was separated from one of sixteen individuals, showing the manner in which the stipes is attached to the central cell, which here appears also with the central area and its surrounding cells: *a*, bilobate form of individual; *b*, *c*, *d*, showing gradation of the outer profile of the cell from concave to convex, following the more or less robust state of the individual, purposely drawn in this way to point out how different the form of an individual cell of the same *Sorastrum* may be under different circumstances, even in the same species.

Fig. 6. The same, group of large individuals from which several baby groups were developed, showing seven individuals still filled with gonimic contents (*a*), two empty collapsed ones (*b b*), and five baby groups (*c*), all of which have (for particular examination) been more or less separated by pressure from their original grouped arrangement. Baby groups 3-6000ths inch in diameter, individuals $1\frac{1}{2}$-6000th inch broad: four groups eliminated in parent cells respectively, *c*; and the other consisting of a group apparently of eight individuals free (that is, with no enveloping cell), *d*.

Fig. 7. The same, the foregoing group with the large individuals only, viz.: —those which still retained their gonimic contents (*a*) and those which were collapsed and empty (*b b*); the contents of the former eliminated to show their rounded, altered forms and more or less atrophied spines, respectively (*c*, *c*, &c.); also two more empty and collapsed individuals, making in all four from which the baby groups had been eliminated; lastly, the fragmental remains of some cells (*d*) which may or may not have been originally developed in this group, which thus seems to have belonged to the sixteen-cell division.

Fig. 8. The same, baby group to compare with that developed from the sporangium, fig 1; size of baby group 3-6000ths inch in diam., individuals $1\frac{1}{2}$-6000th inch broad each.

Fig. 9. The same, form and size of assumed sporangium, filled with gonimic contents of a deep dark sea-green colour, like that of the *Sorastrum*-group, 13-6000ths inch in diameter: *a a*, gelatinous capsule about 3-6000ths inch thick; *b*, proper coat of sporangium.

Fig. 10. *Conococcus elongatus*, n. sp., single cell, 4-6000ths inch in diam., filled with gonimic contents including nuclear (?) vesicle, showing also the peculiar conical extension of the cell-wall.

Fig. 11. The same, in binary division; 12, binary division, with subdivision of conical extension preparatory to quadruple division; 13, quadruple division; 14, eight-cell division; 15, sixteen-cell division; 16, cell-division in four tetrahedral groups of four cells each, sportive form; 17, irregular sixteen-cell division; 18, eight-cell division, with partial extension of the gonimic contents into *all* the radii; 19, eight-cell division, extension of the gonimic contents throughout in one radius; 20, eight-cell division with complete extension of the gonimic contents throughout each radius. The last four groups, including the radii, 6-5400ths inch in diameter.